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VIDEO TAPE RECORDING TECHNIQUES FOR SEASAT RADAR DATA.(U)
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VIDEO TAPE RECORDING TECHNIQUES FOR SEASAT RADAR DATA

by

10) L.G. Rowlandson [redacted] J.J. Renaud
Radar ESM Section
Defence Electronics Division

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ABSTRACT

A dual channel ARVIN/ECHO WRR-441 video tape recorder was used in a system to record SEASAT radar data. The video recorder channels were limited to 6 MHz bandwidth whereas the radar data covered 20 MHz. By designing a phase quadrature recording/play back system an effective bandwidth of 12 MHz was realized which covered the main lobe of the sin X/X radar signal spectrum.

RÉSUMÉ

Un enrégistreur vidéo à bande magnétique ARVIN/ECHO WRR-441 à deux canaux a été utilisé dans un système pour enrégistrer les données du radars de SEASAT. Les canaux de l'enrégistreur vidéo étaient limités à une largeur de bande de 6 MHz tandis que les données du radar couvraient 20 MHz. En concevant un système à lecture/reproduction par quadrature, une largeur de bande effective d'enrégistrement de 12 MHz fut obtenue ce qui couvrait le lobe principal.

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1.0 INTRODUCTION

An ARVIN/ECHO WRR-441 dual channel, 6 MHz bandwidth, recorder was installed at Shoe Cove, Newfoundland to record SEASAT radar data.

The microwave radar signal is monatonically shifted in frequency within the 33.91 microseconds transmitted pulse resulting in an I.F. signal frequency shift from 1.8 to 21.8 MHz. In order to record this signal with the limited video bandwidth of the recorder it was necessary to base band the I.F. and record signals in quadrature.

Base band signals are produced by beating the 1.8 to 21.8 MHz I.F. with a coherent 11.8 MHz signal which folds the spectrum from 0 to 10 MHz. Since the radar pulse spectrum has a sin X/X shape the 6 MHz bandwidth of the video recorder can record a significant part of the pulse power with only the lower level 6 to 10 MHz components lost in the process.

Recording in phase quadrature, as will be shown below, allows the radar signal spectrum to be reconstructed from the two channels of recorded signals with maximum preservation of amplitude and phase information.

2.0 QUADRATURE RECORDING AND SIGNAL RECONSTRUCTION

Since the radar signal is monatonically shifted in frequency within the transmitted pulse the instantaneous intermediate frequency can be written,

$$\omega_i = \omega_1 + \left(\frac{\Delta\omega}{T}\right) t \qquad (1)$$

where

ω_1 = the start frequency (1.8 MHz)

$\Delta\omega$ = the frequency excursion (20 MHz)

T = the pulse duration (33.91 μsecs).

The instantaneous phase is then,

$$\alpha = \int_o^t \left(\omega_1 + \frac{\Delta\omega}{T} t\right) dt$$

$$= \omega_1 t + \frac{\Delta\omega}{2T} t^2 \qquad (2)$$

The I.F. signal which includes time-varying amplitude characteristics can then be expressed as,

$$X(t) = a(t) \cos\left(\omega_1 t + \frac{\Delta\omega}{2T} t^2 + \psi(t)\right) \qquad (3)$$

where,

$a(t)$ = the amplitude variation of the signal with time.

$\psi(t)$ = the time-varying phase of the signal due to propagation and terrain reflection effects.

Referring to Figure 1, $X(t)$ is multiplied in the mixers with phase quadrature signals $K\cos(\omega_o t + \theta)$ and $K\sin(\omega_o t + \theta)$ respectively.

The outputs from the mixers are then,

$$R_1(t) = K\cos(\omega_o t + \theta) \times a(t) \cos\left(\omega_1 t + \frac{\Delta\omega}{2T} t^2 + \psi(t)\right) \qquad (4)$$

$$R_2(t) = K\sin(\omega_o t + \theta) \times a(t) \cos\left(\omega_1 t + \frac{\Delta\omega}{2T} t^2 + \psi(t)\right) \qquad (5)$$

Expanding $R_1(t)$, then,

$$R_1(t) = \frac{k}{2} a(t) \; [\cos\,(\omega_1 t - \omega_o t + \frac{\Delta\omega}{2T} \; t^2 + \psi(t) - \theta)$$

$$+ \cos\,(\omega_1 t + \omega_o t + \frac{\Delta\omega}{2T} \; t^2 + \psi(t) + \theta)]$$

$$= \frac{k}{2} \; a(t) \; [\cos\,(\omega_1 t - \omega_o t) \; \cos\,(\frac{\Delta\omega}{2T} t^2 + \psi(t) - \theta)$$

$$- \sin\,(\omega_1 t - \omega_o t) \; \sin\,(\frac{\Delta\omega}{2T} t^2 + \psi(t) - \theta)$$

$$+ \cos\,(\omega_1 t + \omega_o t) \; \cos\,(\frac{\Delta\omega}{2T} t^2 + \psi(t) + \theta)$$

$$- \sin\,(\omega_1 t + \omega_o t) \; \sin\,(\frac{\Delta\omega}{2T} t^2 + \psi(t) + \theta)] \qquad (6)$$

Terms in $(\omega_1 t + \omega_o t)$ are at too high a frequency to be recorded and can be neglected and $R_1(t)$ can then be expressed as,

$$R_1(t) = \frac{k}{2} \; a(t) \; \cos\,(\omega_o t - \omega_1 t - \frac{\Delta\omega}{2T} t^2 - \psi(t) + \theta) \qquad (7)$$

In the same way $R_2(t)$ can be derived giving,

$$R_2(t) = \frac{k}{2} \; a(t) \sin\,(\omega_o t - \omega_1 t - \frac{\Delta\omega}{2T} t^2 - \psi(t) + \theta) \qquad (8)$$

Referring to Figure 2, in order to reconstruct the radar I.F. Signal $R_1(t)$ and $R_2(t)$ are mixed on play back with quadrature signals m.cos $(\omega_o t + \phi)$ and m.sin$(\omega_o t + \phi)$. The quadrature signals are usually derived from the same coherent signal generator used to produce $R_1(t)$ and $R_2(t)$. This signal generator must be extremely stable in frequency and is therefore usually of the frequency synthesizer type.

The signals produced on play back with mixing can be defined to be,

$$S_1(t) = \frac{m.k.}{4} \; a(t) \; [\cos\,(\omega_1 t + \frac{\Delta\omega}{2T}\, t^2 + \psi(t) - \theta + \phi)$$

$$+ \cos\,(2\,\omega_o t - \omega_1 t - \frac{\Delta\omega}{2T}\, t^2 - \psi(t) + \theta + \phi)] \qquad (9)$$

$$S_2(t) = \frac{m.k.}{4} \; a(t) \; [\,\cos\,(\omega_1 t + \frac{\Delta\omega}{2T}\, t^2 + \psi(t) - \theta + \phi)$$

$$- \cos\,(2\omega_o t - \omega_1 t - \frac{\Delta\omega}{2T}\, t^2 - \psi(t) + \theta + \phi)] \qquad (10)$$

Adding these signals gives,

$$S_o(t) = \frac{m.k.}{2} \; a(t) \; \cos\,(\omega_1 t + \frac{\Delta\omega}{2T}\, t^2 + \psi\,(t) + \phi - \theta) \qquad (11)$$

With the exception of a constant m.k/2 and phase terms ϕ and θ which are time invariant the signal $S_o(t)$ is a replica of the input signal X(t) of equation (3).

3.0 DESIGN OF THE RECORD AND PLAY BACK QUADRATURE SYSTEM

The down converter used to produce base-band signals for recording and the up converter used to reconstruct the radar I.F. signal are shown in Figure 3. The various microwave and I.F. elements used in this design are specified.

The design was tested and final adjustments made using simulated radar IF signals. The adjustment of amplitude and phase balance between quadrature channels was critical. This necessitated not only balancing the up/down converter channels but also the gain of recording and play back amplifiers on the tape recorder itself.

4.0 SUMMARY

The analysis shows that using two quadrature recordings of base-band radar I.F. signals it is possible to reconstruct the signal on play back and to realize an effective recording bandwidth equal to twice the bandwidth of each recording channel.

Video recordings of approximately 25 passes of the satellite were recorded. This data was then used to reconstruct the signal and provide input signals to a wide band optical film recorder.

The optical recordings derived from video recordings are being analysed on the DREO optical correlator system. The results of this analysis will be the subject of a separate report.

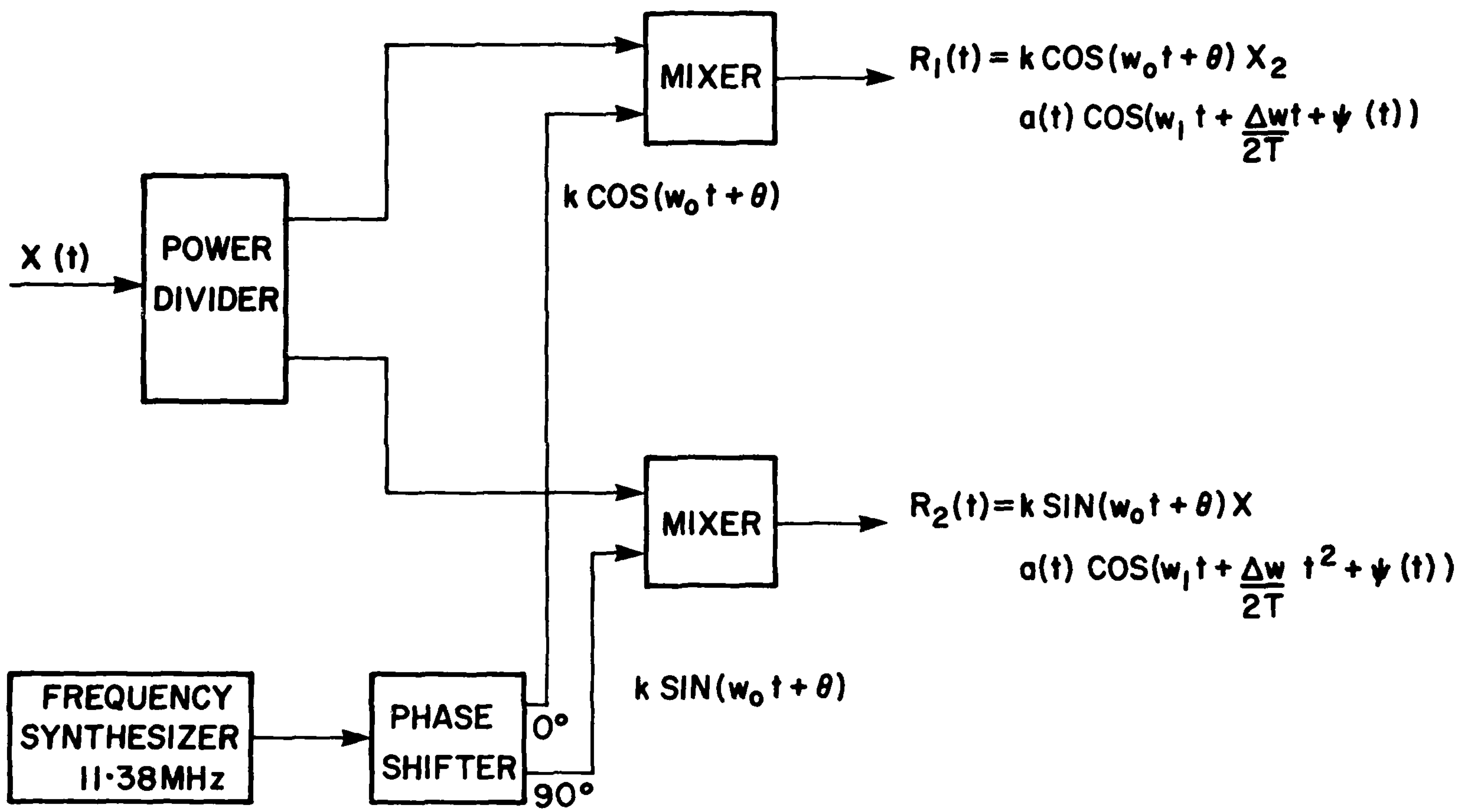

Figure 1 - DOWN CONVERTER

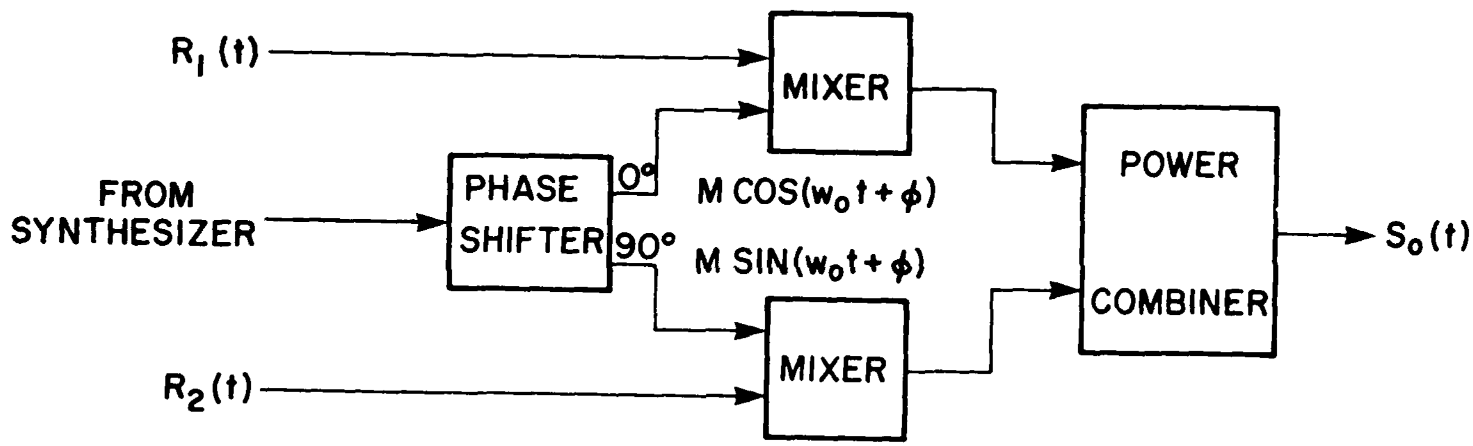

Figure 2 - UP CONVERTER

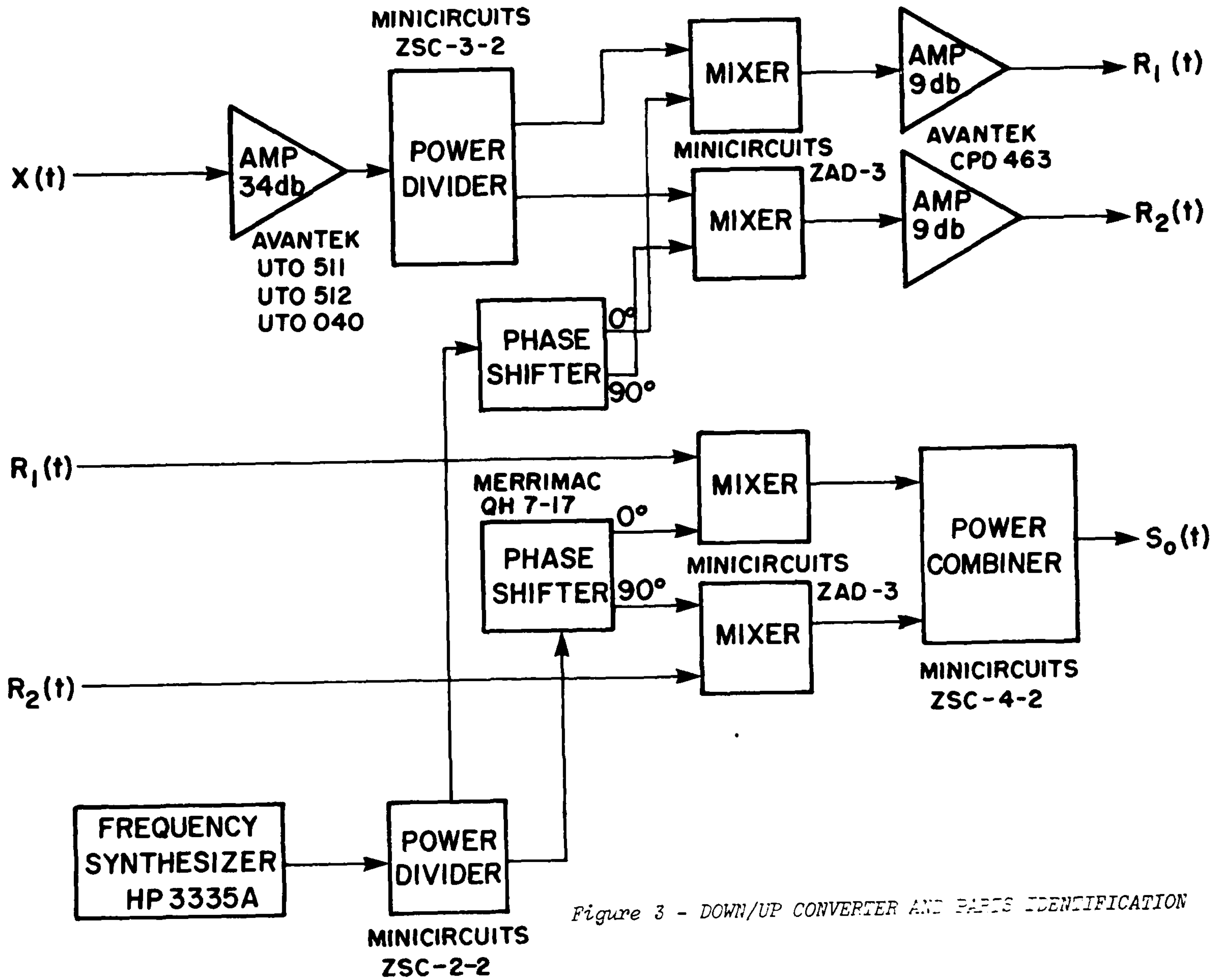

Figure 3 - DOWN/UP CONVERTER AND PARTS IDENTIFICATION

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